

1 Description

2 Optical module and optical system

3 The invention relates to an optical module with a rigid circuit
4 carrier comprising a component-equipped area; an unpackaged
5 semiconductor element arranged by means of flip-chip technology
6 on the component-equipped area of the circuit carrier and a
7 lens unit which is arranged on the side facing away from the
8 component-equipped side of the circuit carrier; with the
9 circuit carrier featuring an opening through which
10 electromagnetic radiation is projected from the lens unit onto
11 the semiconductor element; and with the lens unit comprising a
12 lens holder and a lens arrangement with at least one lens.
13 Generic optical modules are known for example from DE 196 51
14 260 A1.

15 The invention further relates to an optical system with such an
16 optical module.

17 Generic optical modules and systems are used especially in
18 automotive technology. In such cases operation can be with
19 electromagnetic radiation from different frequency ranges, in
20 which case cumulatively to the visible light, with which
21 applications in the exterior area of a motor vehicle typically
22 operate, such as LDW (Lane Departure Warning), BSD (Blind Spot
23 Detection), or (Rear View Cameras), the infrared light which is
24 invisible to the human eye is preferred for applications in the
25 interior of the motor vehicle such as OOP (Out of Position
26 Detection) or for additional outside illumination of a night
27 vision system.

28 High demands are imposed on applications in the interior and
29 exterior area of a vehicle as a result of external influences
30 such as temperature, moisture, contamination and vibration. The

1 typical lifetime for systems in the motor vehicle is around 10
2 to 15 years, with only extremely low failure rates being
3 tolerated, so that the components of an optical system of the
4 type mentioned at the start may only exhibit very slow ageing.

5 Since in many cases the space for installing optical modules or
6 optical systems is very restricted, additional difficulties
7 arise in implementing the optical systems. It is thus extremely
8 difficult using conventional means to construct a hermetically
9 sealed reliable unit consisting of a camera chip (currently CCD
10 or CMOS sensors) and optics.

11 Thus with these types of systems, with which images or similar
12 information are recorded, it is obviously necessary for the
13 optics to have their precise focus at the point at which light
14 is converted into information (e.g. film plane, optical surface
15 of CCD or CMOS sensor). The distance between the camera chip
16 and the optics must therefore either be basically set and fixed
17 once during manufacturing, or the focus is reset for each image
18 (focusing on object, non-concretive rays). This makes such
19 units very expensive to manufacture. Furthermore a quality risk
20 arises as a result.

21 However cameras for specific low-cost applications such as
22 automotive, industry, digital cameras, mobiles, toys etc.
23 should be manufactured where possible, as regards cost and
24 quality assurance aspects, without adjustment procedures
25 between optics and camera chip, that is without making
26 adjustments to the focus on the optical surface of the CMOS or
27 CCD sensor. This basically conflicts with the stated
28 requirements.

29 One possibility for developing a focus-free system is to reduce
30 the sums of the possible tolerances and elements, so that the
31 module or system functions as a result of the design without

1 adjustment in at least one specific distance and temperature
2 range. Where the invention is used for example within the
3 framework of an occupant protection system of a motor vehicle,
4 to which the present invention is however not restricted,
5 sharper images at distances of for example 15 cm to 130 cm as
6 well as at temperatures of for example -40°C to +105°C should
7 be able to be guaranteed. The fewer elements are included in
8 the tolerance chain, the easier this is to implement. A major
9 proportion of the tolerance chain is taken up by the circuit
10 carrier for the camera chip (e.g. CCD or CMOS). Thus for
11 example by using very thin, so-called flexible circuit boards,
12 an attempt is made to include only a very small thickness
13 tolerance. In addition the required solder and if necessary
14 glued connections or such like between the chip and the circuit
15 carrier constitute a large element in the tolerance chain.

16 Using only one lens avoids additional optical tolerances being
17 caused by a complicated lens construction. The lens holder,
18 which is preferably made of plastic and can itself be linked to
19 the lens arrangement in a different way so that an exact
20 optical alignment of the lens arrangement and of the
21 semiconductor element in relation to the lens holder or the
22 lens arrangement respectively can always be ensured.

23 However with systems which largely feature a classical layout
24 consisting of lens and camera chip, with the camera chip being
25 accommodated unpackaged as what is referred to as a flip-chip
26 on a suitable circuit carrier, it is difficult to get around
27 the given overall problems and simultaneously meet the given
28 quality requirements. The lens itself must however be adjusted
29 to the camera chip and feature a defined focusing. This is done
30 by suitable fixing options, for example by screwing, gluing or
31 such like, by means of which the lens is fixed relative to the
32 camera chip to the opposite side of the circuit carrier from

1 the component-equipped surface so that the circuit carrier as
2 well as the adhesive or the screw connection or such like are
3 disadvantageously included in the tolerance chain.

4 The object of the invention is to make available an optical
5 module and an optical system with a semiconductor element
6 arranged on a rigid circuit carrier in which the thickness
7 tolerance of the necessary circuit carrier and look connections
8 possibly required or suchlike are largely eliminated so that
9 with a simple and cost-effective assembly, a reliable optical
10 quality without adjustment and especially focusing effort can
11 be provided and can be maintained over the lifetime of the
12 module or system.

13 This object is achieved with the features of the independent
14 claims. Advantageous embodiments of the invention, which can be
15 used individually or in combination with each other, are
16 specified in the dependent claims.

17 The invention builds on the generic optical module such that
18 between the lens holder and the circuit carrier at least one
19 permanently flexible or springy element is arranged which
20 presses the component-equipped area of the circuit carrier away
21 from the lens holder against at least one stop element that is
22 in positive contact with the lens unit.

23 Unlike the solutions known from the prior art in which the
24 circuit carrier is pressed against a lens holder, the present
25 invention follows a new path whereby the circuit carrier is
26 pressed in the opposite direction by a permanently flexible
27 element, i.e. away from lens holder, and a stop there makes
28 positive contact with the optics. In this way the entire
29 tolerance of the circuit carrier and possible adhesives are not
30 only largely but advantageously completely eliminated. Thus
31 with the present invention a manufacturing technology with

1 especially low tolerances between an unpackaged semiconductor
2 element and a lens unit is made possible.

3 For example the positive contact is implemented by a positive-
4 contact surface embodied on the stop element. In a first
5 development, this can be part of a snap-on connection. To this
6 end the stop element is preferably implemented by a hook
7 embodied on the lens holder. This not only makes the assembly,
8 but also subsequent recycling, especially the disassembly of
9 optics and electronics, especially environmentally friendly and
10 simple.

11 In an alternative development the stop element is part of a
12 screwed or riveted connection or such like, with the stop
13 element preferably being implemented by distance bolts or screw
14 holes arranged on the lens holder which operate in conjunction
15 with a screw, a plastic rivet for example or such like.

16 In accordance with the invention the permanently flexible or
17 springy element is preferably rectangular in shape or annular
18 in shape or such like, preferably embodied as a punched part.
19 This advantageously allows the part to be mass produced.

20 For example permanently flexible or springy elements made from
21 thermoplastic elastomers (TPE), Silicon or such like have
22 proven themselves which preferably simultaneously seal the lens
23 unit against the circuit carrier, especially to protect it
24 against moisture and/or dust etc. In an especially advantageous
25 manner the inventive optical module can be developed by
26 providing a ventilation channel in the connection area between
27 the rigid circuit board and the permanently flexible or springy
28 element. This enables a sealed module to "breathe", especially
29 in the event of large variations in temperature. In the
30 embodiment of the present invention with a permanently flexible
31 or springy element it is possible in a simple manner to

1 incorporate a ventilation channel into the element itself for
2 example. If the optical module is to be used where temperatures
3 vary widely, it can prove sensible to glue an adhesive pressure
4 equalization element or pressure equalization foil over an
5 opening embodied in a flexible element, if necessary also in
6 the lens holder itself.

7 Alternatively or cumulatively porous, permanently flexible or
8 springy elements, especially embodied in foam rubber are of
9 advantage, by means of which "breathing" of the lens can be
10 implemented.

11 The invention finally consists of an optical system with an
12 optical module of the type given above. In this way the
13 advantages of the optical module can also be brought to bear
14 within the framework of an overall system.

15 The invention is based on the knowledge that, unlike previous
16 approaches to the solution, it is possible to press the circuit
17 carrier by means of a permanently flexible or springy element
18 in the opposite direction, i.e. away from the lens holder and
19 against a stop which is in positive contact with the optics, so
20 that a compact highly-integrated module solution with small
21 dimensions is available and which at the same time is simple to
22 assemble and to disassemble and is thereby especially cost-
23 effective.

24 The optical module and the optical system are practically
25 maintenance-free. Especially in the sense of cost saving it is
26 also a fact that no optical adjustment of the optical module is
27 required since this is provided in any event by the geometric
28 design of the stop elements, in which case the tolerance chain
29 is shortened by eliminating the circuit carrier and adhesive
30 tolerance by a further amount. Only the tolerance of the stop
31 element remains in the tolerance chain. This amount is however

1 tool-associated. The optical module in accordance with the
2 invention or the optical system is thus far better than
3 previously known modules in respect of tolerances.

4 The invention can be employed especially usefully in the
5 implementation of video systems, if necessary in combination
6 with radar systems, ultrasound systems or such like in the
7 automotive area.

8 The invention is now explained with reference to the
9 accompanying drawings on the basis of preferred embodiments.

10 The figures show schematic diagrams of:

11 Fig. 1 a perspective part cross-sectional diagram of an
12 inventive optical module;

13 Fig. 2 a side view of the inventive optical module from
14 Fig 1;

15 Fig. 3 the lens holder of an optical module in accordance
16 with the invention with screw holes;

17 Fig. 4 the lens holder in accordance with Figure 3 with a
18 permanently flexible or springy annular element
19 placed on it or formed into it;

20 Fig. 5 the lens holder in accordance with Fig. 3 or 4 with a
21 pre-positioned circuit carrier;

22 Fig. 6 the lens holder in accordance with Fig. 5 with a
23 fixed circuit carrier;

24 Fig. 7 a sectional diagram through the optical axis of an
25 optical module in accordance with the invention; and

26 Fig. 8 a diagram of an optical module in accordance with the
27 invention showing a cross section through the fixing.

1 In the description of the preferred embodiment of the present
2 invention below the same reference symbols refer to the same or
3 comparable components.

4 A lens unit 14; 16, 18, 20; 21 and a rigid circuit board 10,
5 comprising a component-equipped area 10a can be seen in the
6 assembled state of the optical module shown in Fig 1 and 2. The
7 rigidly embodied circuit board 10 shown forms the circuit
8 carrier 10 for an unpackaged semiconductor element 12 sensitive
9 to electromagnetic radiation, which is accommodated here as a
10 flip chip 12, which has the advantage that there are no
11 additional tolerances within the sensor or component (e.g.
12 carrier chip, adhesive, etc.). The rigidly embodied circuit
13 board 10 shown here is in effective contact with a ribbon cable
14 or a flexible circuit board 27, with solder pads 28 being
15 provided at the opposite ends of said cable, so that an
16 electrical contact between the optical module and a circuit
17 board (not shown), for example by iron soldering using the
18 solder pads 28, can be established.

19 The semiconductor element 12 is disposed on the circuit carrier
20 10 via solder bumps 30. The semiconductor element 12 is
21 disposed by flip-chip technology on the circuit carrier 10. So
22 that electromagnetic radiation can reach the semiconductor
23 element from the lens arrangement 16, 18, 20; 21 arranged on
24 the side of the circuit board 10b facing away from the
25 component-equipped area 10a of the circuit carrier 10, the
26 rigid circuit carrier 10 features an opening 24. Likewise the
27 permanently flexible or springy element 22 arranged between
28 lens holder 14 and circuit carrier 10 or its second surface 10b
29 has an opening 32. Through these openings electromagnetic
30 radiation can reach a surface 34 of the semiconductor element
31 12 sensitive to electromagnetic radiation.

1 The semiconductor element 12 can be designed in accordance with
2 the prior art as a CMOS or CCD for example. A glued connection
3 can also be used in addition to the solder connection 30. For
4 strengthening an underfill (not shown) can be applied. To
5 protect the rear of the expensive semiconductor element 12
6 against outside light radiation and/or environmental
7 influences, a globtop 26 can be provided. To permit ventilation
8 of the optical module with temperature variations, especially
9 strong ones, a groove (not shown) for ventilation can for
10 example be provided in the flexible element 22. Likewise it is
11 possible to arrange a glued pressure equalization element on an
12 opening (not shown) in the flexible element 22 or in the lens
13 holder 14.

14 Preferably a lens arrangement 14; 16, 18, 20; 21 with a number
15 of lenses 16, 18, 20 and if necessary at least one diaphragm 21
16 is provided in the form of a package. The optical quality can
17 be improved by a lens with a number of lenses, which is also
18 possible within the framework of the present invention,
19 especially since it is possible to work with fine tolerances
20 here. The lenses 16, 18, 20 and the diaphragm 21 are formed so
21 that they assume a defined position relative to one another
22 within the lens holder 14. Furthermore at least one of the
23 lenses 20 is designed so that this lens 20 (as for example
24 shown in Fig. 7 and 8) operates via locking means 38 in
25 conjunction with the lens holder 14 and thus also assumes a
26 defined position in relation to the lens holder 14 and finally
27 in relation to a semiconductor element 12. In this way all
28 lenses 16, 18, 20 or diaphragms 21 are adjusted in relation to
29 the semiconductor element 12.

30 The circuit carrier 10 and lens unit 14; 16, 18, 20; 21 are
31 adjusted in accordance with the invention using the at least
32 one permanently flexible or springy element 22 between lens

holder 14 and circuit carrier 10, which presses the component-equipped area 10a of the circuit carrier 10 away from the lens holder 14 against at least one stop element 13; 35, which is in positive contact with the lens unit 14; 16, 18, 20; 21.

Preferably a surface to make the positive contact 37 is formed for this purpose in the stop element 33; 35.

In the exemplary embodiment in accordance with Fig. 1 and 2 the stop element 13 is for example part of a snap-in connection, which is implemented by a hook arranged on the lens holder 14. Said positive-contact surface 37 is embodied on the hook 13 such that the component-equipped surface 10a lies against this surface 37.

Fig. 3 shows an alternate exemplary embodiment in accordance with the invention. In this case the stop element 35 is part of a screwed or riveted connection, with spacer elements 35 being arranged on the lens holder 14 as a screw hole.

Fig. 4 shows the lens holder 14 in accordance with Fig. 3 with an annular permanently flexible or springy element 22 being arranged on it. Depending on choice of material, the element 22 can also be formed for example by means of a two-component injection process or such like on the lens holder 14. It can be clearly seen how positive-contact surfaces 37 are formed on the end of the screw holes 35 facing away from the lens unit, the function is which is described below.

Fig. 5 shows the lens holder 14 in accordance with Fig. 3 or 4 with a pre-positioned rigid PCB circuit carrier 10, with this carrier 10 not yet making positive contact with the positive-contact surfaces 37 of the spacer elements 35. In other words - the circuit carrier 10 is not yet pushed downwards over the system onto the permanently flexible element 22.

1 Fig. 6 shows the lens holder 14 in accordance with Fig. 5 with
2 a fixed PCB circuit carrier 10. Fixing elements such as screws
3 33, plastic rivets or similar elements are inserted into the
4 spacer elements 35 until these fixing elements rest on the
5 positive-contact surface 37. In this way the flip-chip surface
6 or component-equipped surface 10a of the PCB circuit carrier is
7 aligned in a defined way for the circuit carrier 10.

8 Fig. 7 shows this in a diagram with a cross section through the
9 optical axis and Fig. 8 in a diagram with a cross section
10 through the fixing of the optical module in accordance with the
11 invention. It can be clearly seen how the permanently flexible
12 or springy element 22 presses the component-equipped surface
13 10a of the circuit carrier 10 against the fixing elements 33.
14 In the prior art the circuit carrier has previously been
15 pressed against a lens holder. The present invention now
16 follows a new path whereby the circuit carrier is pressed by
17 means of a permanently flexible or springy element 22 in the
18 opposite direction, i.e. away from the lens holder 14 and a
19 stop 13; 33, 35 there makes positive contact with the optics.
20 In this way the entire tolerance of the circuit carrier 10 and
21 possible adhesives are completely eliminated.

22 The present invention starts with an optical module with a lens
23 unit which comprises a lens holder 14 in which a lens
24 arrangement consisting for example of three lenses 16, 18, 20
25 and a diaphragm 21 is employed. Preferably the lenses 16, 18,
26 20 and the diaphragm 21 are uniquely aligned to each other and
27 in relation to the lens holder 14 by their geometrical design
28 so that no further optical adjustment of the optical module is
29 necessary. The lens holder 14 is further connected via at least
30 one stop element 13: 35 embodied on the lens holder 14 with the
31 component-equipped area 10a of a rigidly embodied circuit board
32 10 which simultaneously acts as a circuit carrier for an

1 unpackaged semiconductor element 12 sensitive to
2 electromagnetic radiation so that for the first time the
3 thickness tolerance of the circuit carrier 10 and any glued
4 connections advantageously is not included in the tolerance
5 chain of generic optical modules or systems. Since in
6 accordance with the invention the semiconductor element 12 is
7 arranged at a defined position in relation to the other optical
8 elements, i.e. especially the lenses 16, 18, 20 or the
9 diaphragm 21, the type of circuit carrier 10, e.g. FR4, CEM,
10 etc..., no longer has to be fixed, as has previously been the
11 case. Instead „normal“, non-critical and thereby cheaper
12 circuit carriers can be used.

13 The features of the invention disclosed in this description, in
14 the drawings and in the claims can be of importance both
15 individually and in any combination for implementing the
16 invention. They are especially suitable for applications in the
17 interior or exterior area of a motor vehicle.

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